Water-quality model development and application in Barnegat Bay-Little Egg Harbor Estuary, New Jersey

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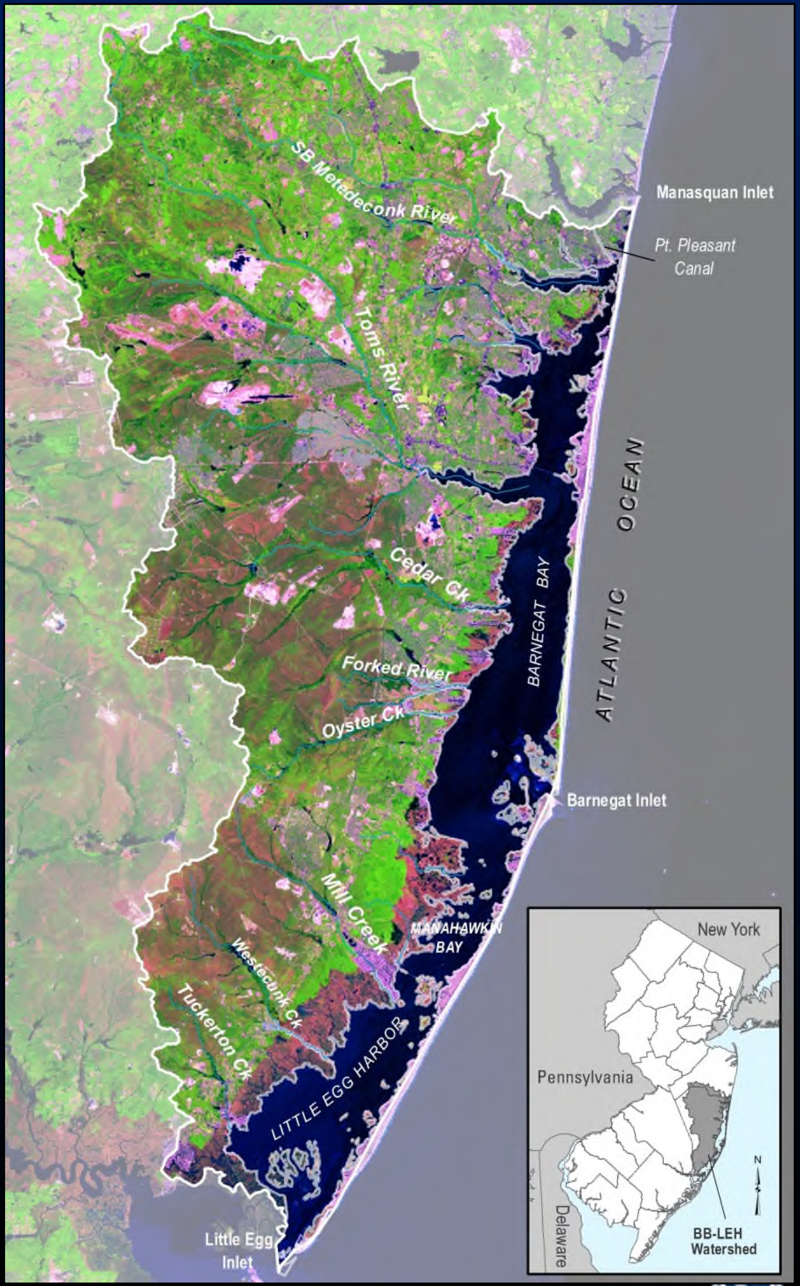
Study Area

- 107 sq mi, long and narrow bay behind "Jersey Shore" beaches
- Shallow (3-20 ft deep); poorly flushed; tide range up to ~3 ft
- 3 outlets to ocean: Pt. Pleasant Canal (to Manasquan), Barnegat Inlet, Little Egg Inlet
- Toms River, Metedeconk River and minor streams provide freshwater inflow
- Oyster Creek Nuclear Plant adds high flow pulses plus thermal load
- Bay is under pressure from urbanization of watershed. Impacted by nutrient enrichment; highly eutrophic (NOAA, 2007)



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Project Objectives

- Construct a water quality model of the bay to help improve understanding of the response to stressors
  - Use WASP multi-dimensional fate and transport code
  - Simulate spatial and temporal distribution of potential TMDL parameters (DO, nutrients, chlorophyll, TSS)
  - Account for other eutrophication processes (oxygen demands, Si, algae, pH, TIC, sediment diagenesis)
- Collect and integrate data from related field activities and other sources
- Calibrate and validate model
- Apply model to evaluate NJDEP management alternatives for bay water-quality restoration

Data Collection and Integration

- NJDEP water quality monitoring
  - Continuous data
  - Discrete data
  - Intensive data
- NJWSC flow and water quality monitoring
  - Continuous data (3 inlets, 1 bay xsection, 1 tributary)
  - SOD/benthic flux, suspended sediment
- Other
  - Meteorological data
  - Kinetic coefficient data
  - GIS data (basin characteristics, SAV distribution, etc)

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Model Construction

- *Develop linkage with ROMS model of Barnegat Bay to provide hydraulic inputs to WASP (current work)*
- Initial model
  - Simulate DO, CBOD, SOD, reaeration
- Full model
  - Incorporate/estimate nutrient sources/sinks
  - Incorporate benthic flux/sediment diagenesis, suspended sediment
  - Incorporate phytoplankton, SAV effects

Boundary Concentrations

Streams

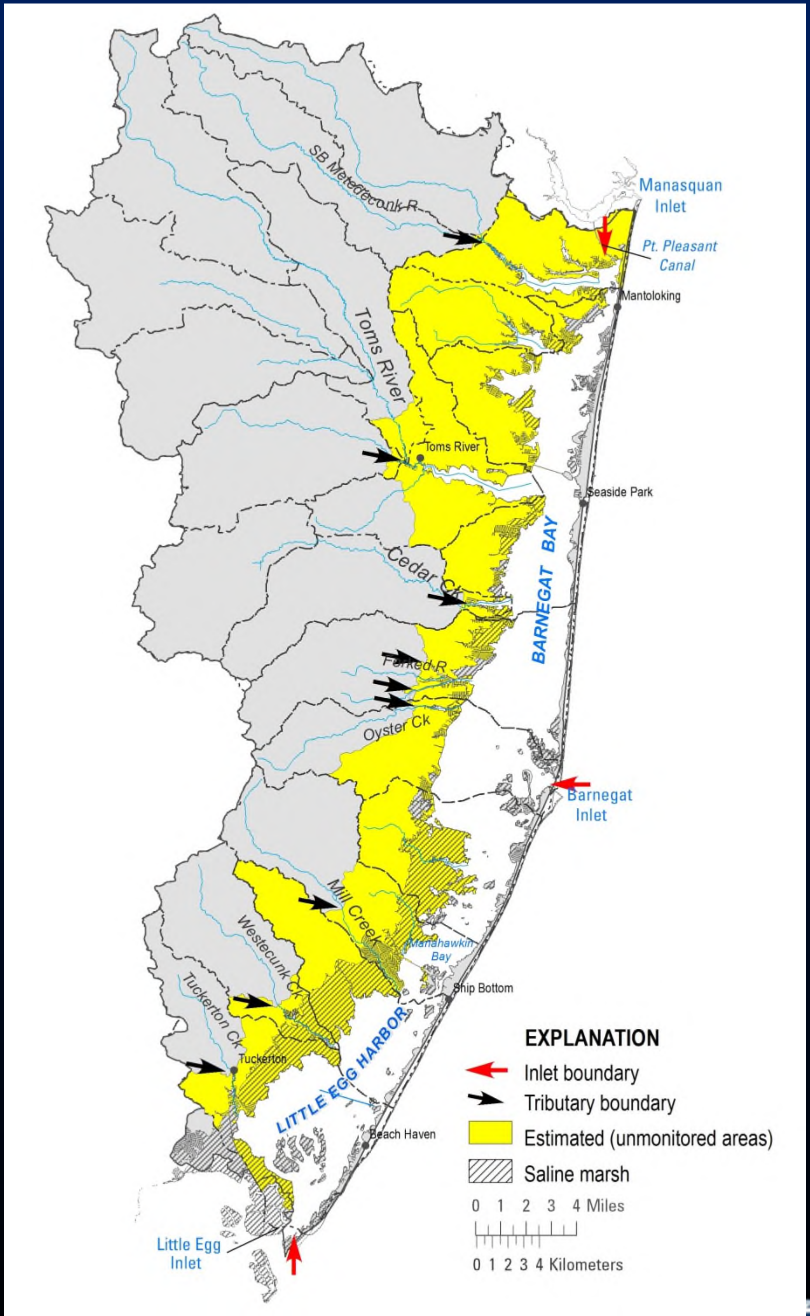
Specification of N and P species, DO, CBOD, pH/Alk, Chl-*a*, Si (temporal series)

Inlets

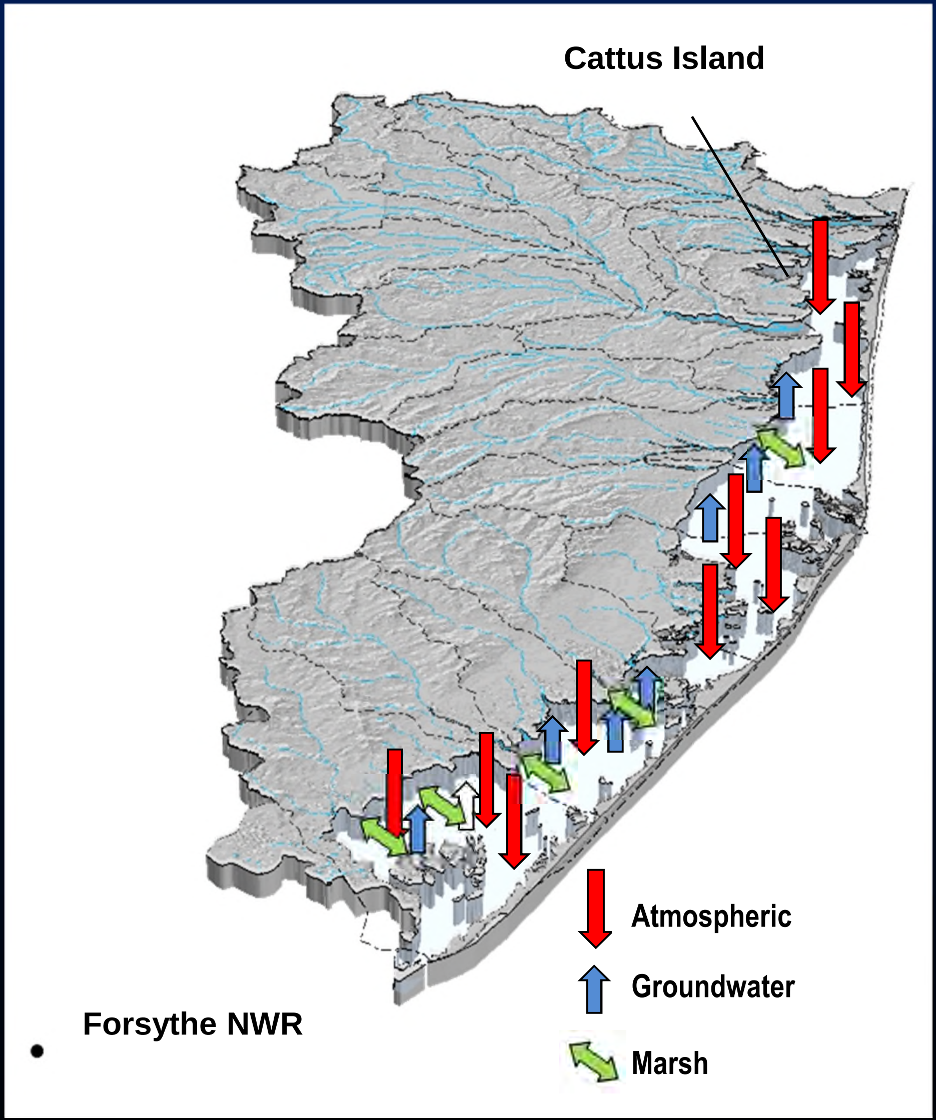
Specification of N and P species, DO, CBOD, pH/Alk, Chl-*a*, Si (temporal series)

Other

Minor boundaries - to incorporate broader hydrodynamic model domain



Boundary Loads



Atmospheric deposition

N measured at 2 stations, scaled to surface area and applied to layer 1

Unmonitored Subbasins

N, P, Si, CBOD based on loading in hydrologically similar basins

Salt marsh

Retention/transformation/export of N, P, Si, C from upland sources and effects of tidal exchange

Direct GW discharge

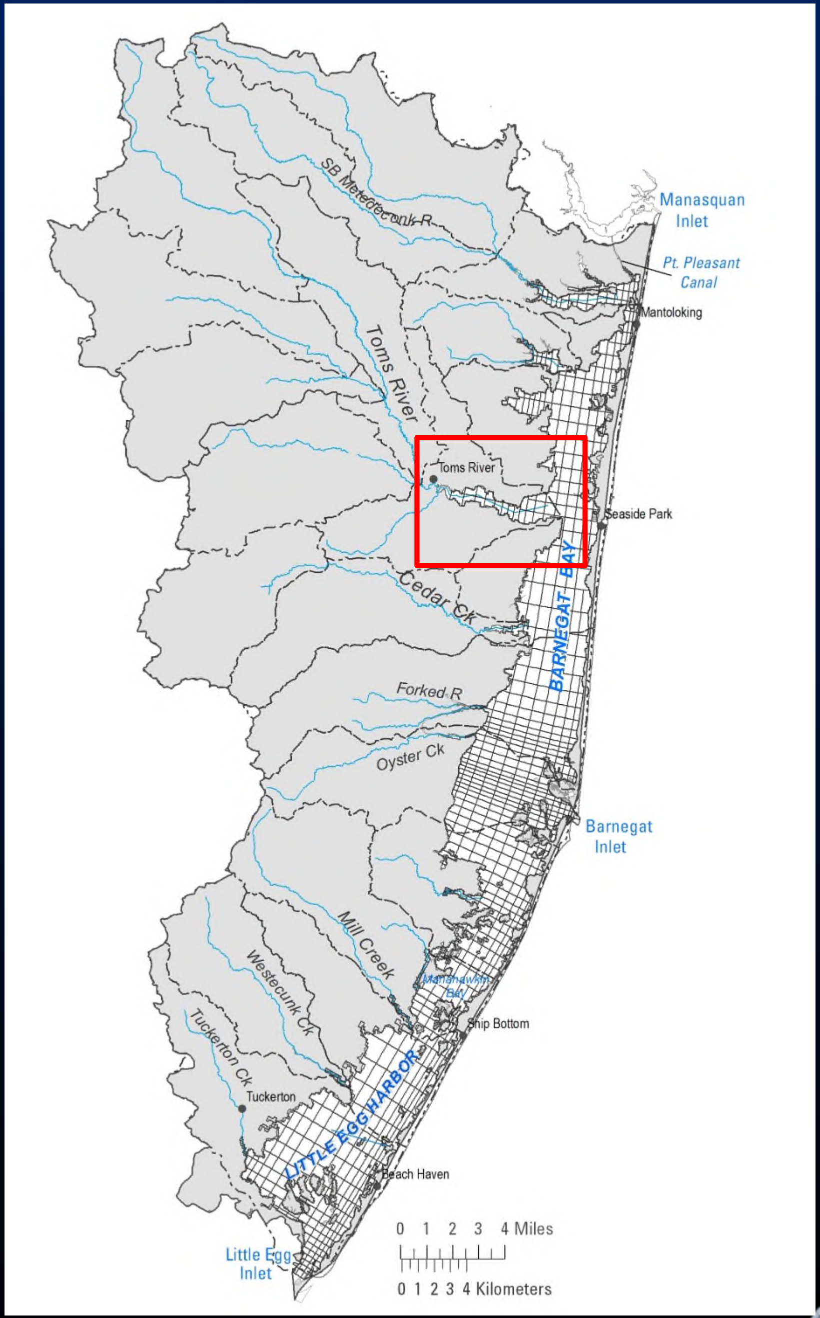
N, P at western bayshore boundary

WASP Grid Design

- WASP requires a coarser grid from ROMS due to computational and operational limits
- Goals of WASP grid design
  - Capture horizontal water quality gradients via delineation of generalized hydrochemical zones
  - Represent vertical stratification of water quality
- Outcome of upscaling from ROMS to WASP grid
  - WASP segment size is ~40x larger, 3 layers
  - Time step also upscaled: ROMS = 5s, WASP = 60s

Grid Map

- 2568 total segments
- 756 segments/layer
- Example area of water quality refinement (Toms River)



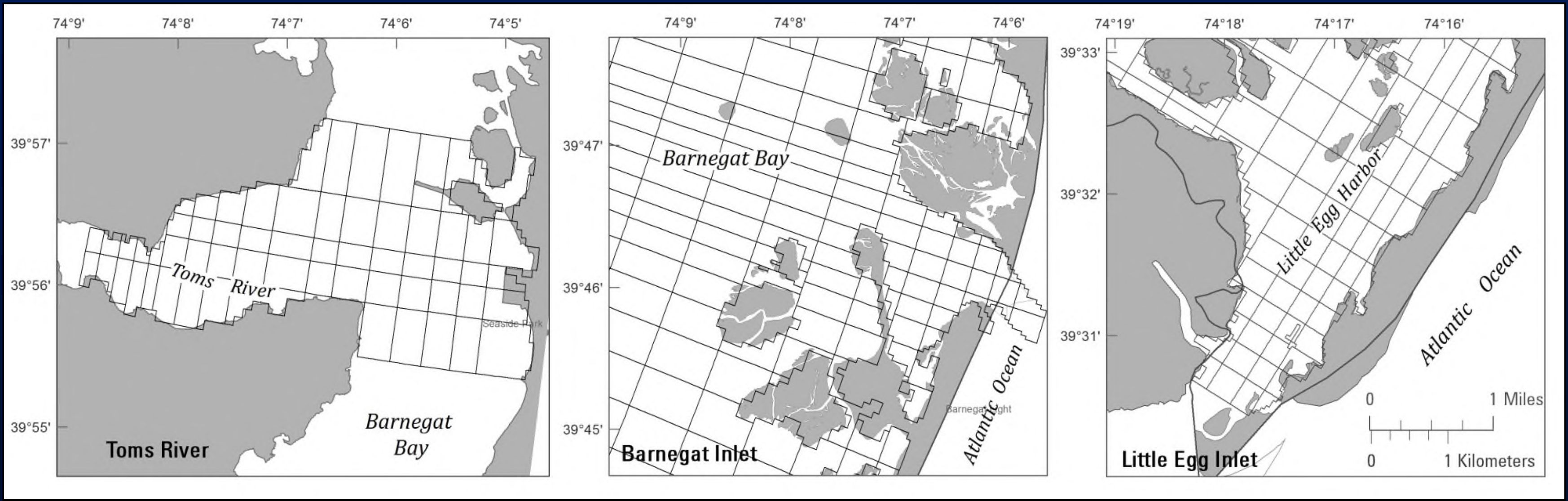
Hydrodynamic Linkage - definition

- *ROMS and WASP are not linked, so this connection must be developed*
- Collaborative effort--creating linkage files from ROMS output (USGS-Woods Hole), testing linkage files in WASP (USGS-NJ)
- Data transfer via binary linkage file
  - Cell mapping between model grids
  - Flow data (volume, depth, velocity, dispersion)
  - Salinity, temperature
  - Sediment

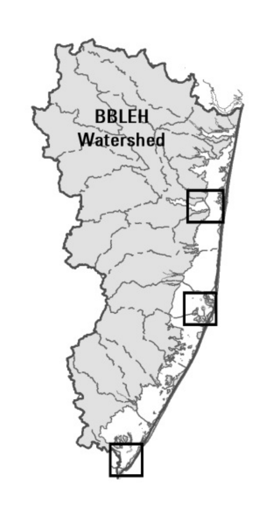
Hydrodynamic Linkage - approach

- Use bay submodels before full grid test
- Compare to EFDC-WASP linkage files
- Develop evaluation protocol
    1. Check water mass balance
    2. Import test case linkage file into WASP
    3. Check cell mapping, boundary conditions, flow data
    4. Run WASP
    5. Check conc mass balance (conservative tracer)
    6. Compare relevant ROMS output to WASP output
    7. Consider accuracy of spatial/temporal upscaling

Hydrodynamic Linkage - bay submodels

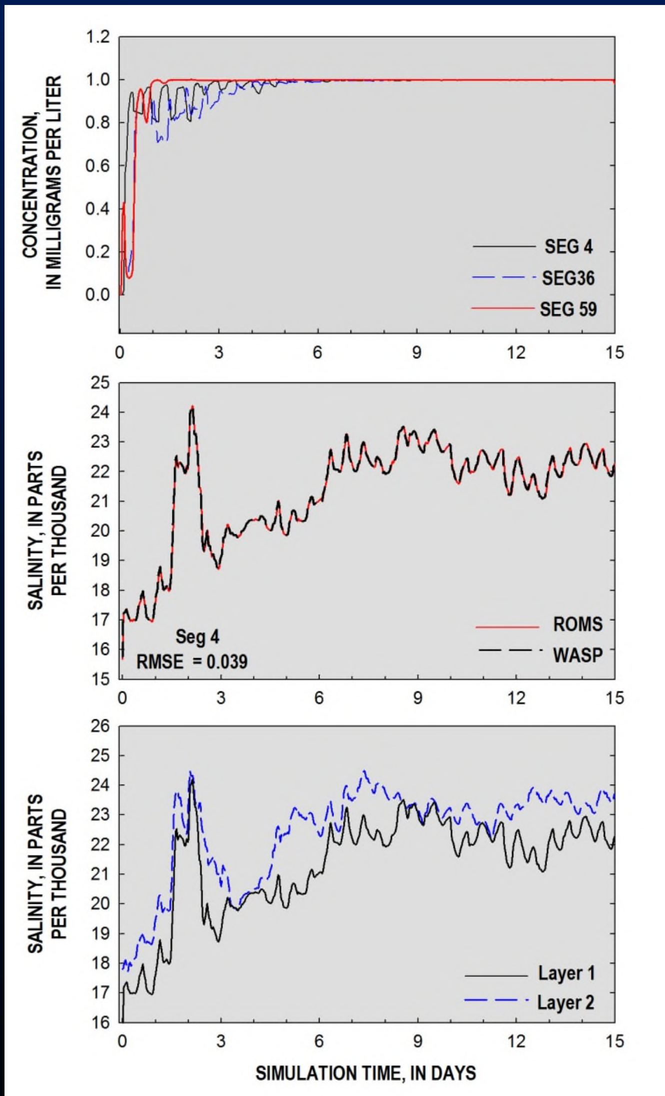


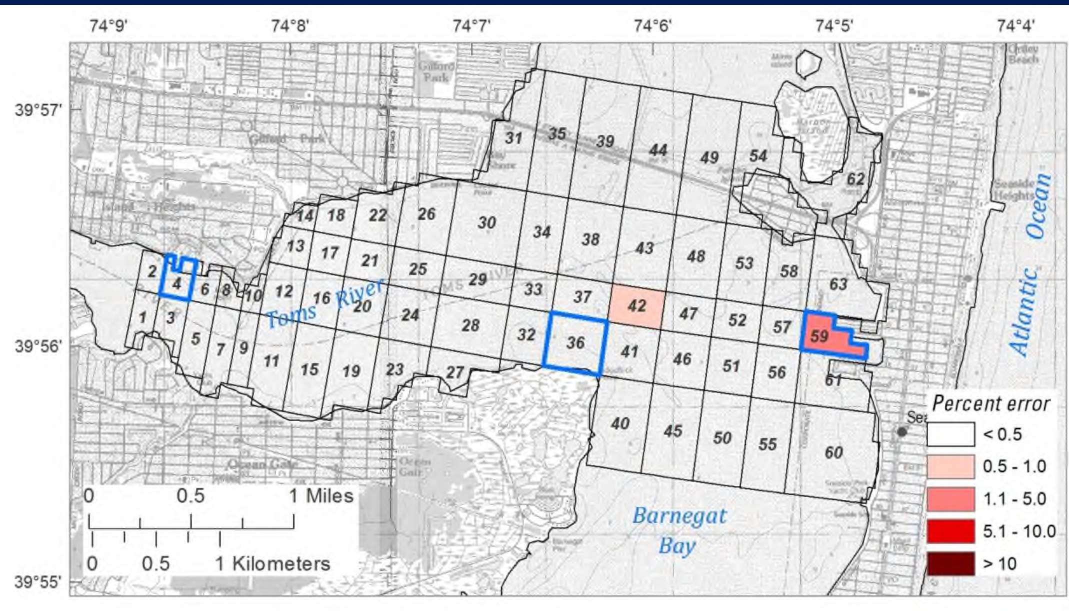
Sub-regional test areas



- *Toms River -- fresh to saline water transition*
- *Barnegat Inlet -- main circulation exit, high flow, tidal*
- *Little Egg Inlet -- main circulation entrance, high flow, tidal*

Hydrodynamic Linkage - example testing output





Toms River test case

- *Verify water mass balance (ideally ≤1% error)*
- *Verify concentration mass balance*
- *Verify match of relevant ROMS and WASP output*
- *Verify representation of system (e.g., stratification)*

Simulation Period and Calibration

- Simulation period
  - Spring-Summer 2012
- Compare model results to observed data
  - Focus on the three intensive sampling events
  - Adjust kinetics
  - Adjust estimated boundary concs and loads

Model Application

- Testing of water-quality management scenarios
  - Increased freshwater flow
  - Closure of nuclear plant
  - New baseline condition
  - Nutrient loads – target reduction, refined target reduction
  - Nutrient loads – attain target response
  - Engineered solution (new inlet)
- Use WASP output to drive other models
  - Ecosystem models – NPZ and EwE (Rutgers)